

Is There a Spatial Analogue of the Passage of Time?

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It is exceedingly frequent for people to speak of the ‘passing of time’. We do not, on the other hand, speak of the ‘passing of space’. There do not seem to be any common locutions concerning spatial passage analogous to those of time’s assumed passage. Further, there is a long held belief in the philosophy of time that there is no spatial analogue of the passage of time. This opinion does not take into account circumstances that cannot be noticed in day-to-day existence and which indicate that there is such a spatial analogue.

Key Words: Temporal passage, spatial analogue, cosmic time, spatial locutions

Introduction

It seems almost undeniable that everybody has an awareness of time elapsing, passing, flowing, or otherwise progressing [Lucas, 1973: 13; Schlesinger, 1980: 31; Horwich, 1987: 4; Penrose, 1989: 391; Craig, 2000: 138; Prosser, 2007: 75; Price, 2011: 276]. This ‘transience’ that typifies time appears, *prima facie*, to be something that is absent from space. Another way of expressing this absence is to claim that there is no spatial analogue of the passage of time (at least in the actual universe that we inhabit). Indeed, most philosophers agree on this position [e.g. Maudlin, 2007: 108; Dainton, 2010: 7]. The agreement is due to holding either of the two following reasons. The first is that an absence of a spatial analogue of the passage of time is taken as being one of the (several) differences between space and time. The second reason is that the passage of time itself is not accepted as being a genuine feature of the universe and therefore there is no spatial analogue.

Although the spacetime interpretation of relativity theory implies that there is no objective passage of time, a few prominent cosmologists have recently been advancing the opposite view about time [e.g. Ellis, 2012; Unger & Smolin, 2015], i.e. that the passage of time is objective and is consistent with relativity theory. It turns out that relativistic cosmology is crucial in addressing the question of whether there is a spatial analogue of the passage of time, independent of one’s position on time’s passage. The current paper aims to provide an answer to the question of a spatial analogue within the context of modern cosmology.

Metaphors and the Passage of Time

In the philosophical study of time, the passage of time has a controversial ontological status (i.e. the objective existence of the passage of time remains contentious) with an essential dichotomy of opinion on this issue. Many philosophers, such as Donald Williams, have strongly contended that there is no temporal passage. Williams goes so far as to state that the passage of time is a “myth” in his oft cited classic article, ‘The Myth of Passage’

[Williams, 1951]. Those who take the passage of time as not physically real treat the notion of the ‘passage of time’ and its many synonymous expressions as motion metaphors (e.g. “as time goes by”). The status of the motion metaphors is itself a topic in the philosophy of time [Smart, 1949: 483; Grünbaum, 1971: 201-203; Lawrence, 1975: 198-200; Kroes, 1984: 436; Levison, 1987: 351-352; Dowden, 2013; Ludlow, 2015] and these metaphors retain a solid place in daily thought and everyday conversation. In the face of multiple, influential arguments against temporal passage, there are a minority of philosophers who fervently contend that there is a genuine passage of time, as suggested by our feelings and ‘common-sense’ [e.g. see: Čapek, 1966; Otten, 1978; Schlesinger, 1982; Craig, 2000; Markosian, 2004; Zimmerman, 2008]. One such philosopher was John Wild, who wrote: “[T]he image of world-time as a vast stream coming down from the past, moving through the present, and into the future *is correct*” [Wild, 1954: 545, italics added].

Nonetheless, at least everyone agrees that time *seems to* advance on and on [Eddington, 1929: 68; Schlesinger, 1982: 501; Price, 2011: 276]. We all constantly observe events happening, the seasons coming and going, everything getting older, etc. It is obvious that none of us are able to avoid (in any practical way) the ‘onslaught’ of the (apparent) passage of time and its inevitable outcomes of change, ageing, decay and death [Fraser, 1987: 4]. In other words, we all seem to have an ‘experience’ of the passage of time regardless of whether this passage is real or not, as the poet Thomas Carlyle once wrote: “The illimitable, silent, never-resting thing called Time, rolling, rushing on, swift, silent, like an all-embracing ocean-tide, on which we and all the universe swim like exhalations...” [Carlyle, 1841].

It is a pragmatic fact that, at a phenomenological level, we have an awareness of the passage of time, which continues no matter what the origin of this awareness may be [Dainton, 2010: 104]. This phenomenological fact allows an analysis to be conducted of the issue of whether there is a spatial analogue without having to identify the underlying causes of such awareness.

Passage and Realist Theories of Time

The dichotomy of opinion over the reality of temporal passage has its sophisticated philosophical articulation in the dialogue between the advocates of the two competing realist theories of time: the Dynamic View (also called the A-Theory of time) and the Block View (also called the B-Theory of time). What characterises a theory of time as being realist? Friedel Weinert has provided a succinct description as follows: “To be a realist about time means to regard time ... as a parameter of the physical universe ... Time possesses an independent physical reality, irrespective of whether humans observe it or not” [Weinert, 2013: 99].

The ontological status of temporal passage is an especially disputable point in the debate over the two realist theories. This should not be surprising as the Dynamic View accepts that the passing of time is a fundamental aspect of reality whilst the Block View denies the existence of any objective temporal passage. Since these two views of time are philosophical in character, experimental tests cannot settle the issue. Neither will we attempt to decide the matter here, nor will we need to do so.

The chief claims of the two competing realist theories of time are, however, relevant to our discussion and may be concisely stated. The Dynamic View embraces the notion of temporal ‘becoming’, i.e. the coming into existence of events that is characteristic of time passing. In this view, time may be represented by a line with an arrowhead at one end which always points one way (towards the future) and confers an objective direction of time. Time’s dynamic nature may then be represented by the arrowhead ‘advancing’ into the future so that

more events come into existence with this advance and the time interval from the beginning of the universe increases. Whether an event is past, present, or future is determined by the passage of time. The present moment in time holds a privileged ontological status in the Dynamic View as it is when events come into being [Seddon, 1987: 3-6; Price, 1996: 12; Dainton, 2010: 7; Bardon, 2013: 80-81]. Whilst it is the case that the Dynamic View is held by only a minority of analytic philosophers, they do constitute a significant group of contemporary thinkers on the nature of time [e.g. Bourne, 2006; Craig, 2000; Crisp, 2007; Esfeld, 2015; Forrest, 2008; McKinnon, 2013; Maudlin, 2007; Fiocco, 2007; Pooley, 2013].

On the other hand, the passage of time in the Block View is not objective and is rationalised away as being a psychological phenomenon. Past, present, and future are only relative to particular observers (just as ‘here’ and ‘there’ are relative terms), i.e. all events have equal reality regardless of when they occur [Seddon, 1987: 7-8; Price, 1996: 12-13; Dainton, 2010: 7-8; Bardon, 2013: 81-82]. Human beings are extended entities across time from birth to death. The present moment, although seemingly privileged from human perspective, has no special ontological status. We are only aware of events in our (subjective) present as our attention is changed from earlier to later and this is subsequently manifested to us as our memories.

It is uncontroversial that there are a number of similarities and differences between space and time. Many philosophers have commented in detail about these [e.g. see: Reichenbach, 1958; Smart, 1963; Lucas, 1973; Hinckfuss, 1975; Schlesinger, 1980; Heller, 1984; Taylor, 1992; Skow, 2007]. One academic philosopher who has written extensively on the ontology of space and time was the late Richard Taylor. In 1963, Taylor published the first edition of his well-received philosophy text *Metaphysics*. In this book, Taylor outlined (and repeated in later editions) what is usually taken as the biggest difference between space and time. He expressed this difference as follows: “The one thing about time that has always been the greatest stumbling block to comparing it with space, however, is its *passage* or *flow*...” [Taylor, 1963: 74, italics in original].

Fast forward fifty-odd years and we still find comparable statements appearing in philosophical treatises, such as in Barry Dainton’s comprehensive book, *Time and Space*: “We speak of “time passing”, “the march of time”, “the flow of time” and there are no spatial analogues of these locutions ... We can think of the present as advancing into the future, or the future advancing towards the present ... This process is often called “temporal passage”, and has no obvious spatial counterpart” [Dainton, 2010: 7].

There have been many of these comparable statements in the philosophical literature indicating the absence of a spatial analogue of the passage of time [e.g. Broad, 1968 (1938): 124; Gale, 1968: 214; Mellor, 1981: 116-118; Kroes, 1984: 442; Markosian, 1993: 835; Schlesinger, 1994: 63; Mellor, 1998: 95; Maudlin, 2007: 108; Olson, 2009: 440]. These statements show that there is a *widespread* opinion, which continues to be held that the passage of time does not have a spatial analogue (or counterpart). The notable exception appears to be the philosopher William Newton-Smith who suggested that the “uniform motion of bodies” in space might qualify as a spatial analogue of the passage of time [Newton-Smith, 1980: 42]. However, this suggestion *cannot* actually qualify as a spatial analogue since it does not concern space itself but only the motion of bodies in space.

We do feel that whereas time seems to always advance, space seems to be fixed — time being completely unlike space in this respect (or so it appears). Yet, is it really the case that there is not any spatial analogue of the passage of time? Further, if there is such an analogue, one would expect that there ought to be common locutions about the movement of space, but

are there any? If these locutions do not exist, does this indicate that there really is not any spatial analogue of the passage of time? We shall address these questions below.

What Modern Cosmology Shows

There has been for several decades, a general acknowledgement that modern cosmology would play an essential role in gaining a deep understanding of time [Whitrow, 1980: 344; Smolin, 1997: 262]. The observable universe at large scales is homogeneous and isotropic to a very good approximation. If we make this approximation about the whole universe then what results in the context of the General Theory of Relativity is known as the Friedmann-Robertson-Walker cosmological model. The model provides an accurate description of the observable universe [Smeenk, 2013a: 613]. The structure of this model is specified by its spacetime interval, denoted Δs . The spacetime interval is an invariant quantity for all observers and its square is given by:

$$(\Delta s)^2 = c^2 (\Delta t)^2 - R^2(t) (\Delta \Omega)^2$$

where Δt is an interval of cosmic time (see below), $\Delta \Omega$ is the corresponding spatial distance, c is the speed of light in vacuum, and $R(t)$ is the scale factor of the universe at a given value t of cosmic time [Rindler, 2006: 367]. Cosmic time is defined statistically as the time that would be measured by a clock sharing the *average* motion of matter in the universe [Rindler, 2006: 359; Smeenk, 2013b: 205].

If we take the spacetime interval at a particular value of cosmic time (say $t = t_1$) then $\Delta t = 0$ and Δs gives the spatial distance between two locations at cosmic time t_1 . The spatial distance at a later value of cosmic time (say $t = t_2$, $t_2 > t_1$) will differ from the spatial distance at time t_1 by the ratio of the scale factors at these two times, $[R(t_2)/R(t_1)]$. If this ratio is greater than one then spatial distances will have increased at later cosmic times [Sciama, 1971: 111]. Although such an increase is (in practice) not directly measurable, it may be separately inferred from other quantitative measurements [Hobson et al, 2006: 371]. The ratio $[R(t_2)/R(t_1)]$ being greater than unity is empirically confirmed and shows that the spatial distances between objects on cosmological scales are getting larger and larger at later and later values of cosmic time.

The explanation accepted by most physicists and scientifically literate philosophers for the increase on cosmological scales is that (three-dimensional) space is *enlarging*. This expansion of space is also inferred from the observed redshift in the wavelength of stellar light. Measurements of the light from more and more distant objects show no exceptions to the increase of redshift which continues to confirm that the universe is expanding [Hamilton, 2014: 73]. The galaxies are not hurtling *through* space but rather the volume of space itself is growing, i.e. the actual space (and therefore the distances) between galaxies is getting bigger [Misner et al., 1973: 719; Ray, 1991: 196-197; Cushing, 1998: 264; Harrison, 2000: 276; Singh, 2004: 270; Hoyng, 2006: 222; Kirk, 2007: 3; Close, 2009: 130; Penrose, 2010: 61; Al-Khalili, 2012: 38]. Physicist Brian Greene summarised the accepted explanation in his popular book, *The Fabric of the Cosmos*, as follows: "...general relativity says that for billions of years space has been stretching. And as it has swelled, space has dragged the galaxies away from each other ... the origin of the outward motion is not an explosion that took place within space. Instead, the outward motion arises from the relentless *outward swelling of space itself*" [Greene, 2004: 231, italics added].

Although this explanation has been questioned by a few cosmologists over the last couple of decades, it has withstood criticism [cf. Davis & Lineweaver, 2003; Grøn & Elgarøy,

2007]. Further, the two recent detections of gravitational waves (i.e. *ripples* in the ‘fabric’ of space) by the U.S. Laser Interferometer Gravitational-Wave Observatory [Abbott et al., 2016a; 2016b] constitutes compelling evidence that physical space has an ‘elastic’ nature and therefore quite capable of expanding.

The Spatial Analogue of Passage and its Interpretations

The issues concerning a spatial analogue of temporal passage have been lingering for years at the margins of debates about the nature of time. Although we have characterised the spatial analogue of the passage of time up to this point by just drawing a spatial contrast with time passing, it is possible to give a better description of what is meant by ‘spatial analogue’. A standard definition of analogue is that something is similar in some respects to something else. We may then reasonably state that the spatial *analogue* should be some property of space that has enough similarity to the (apparent) passage of time. In light of our human experiential perspective of time, it is appropriate to ask whether there is any *property* of space that displays such similarity.

The expansion of space (as described in the previous section) requires spatial volumes on cosmological scales to be larger at later values of cosmic time. This ‘swelling’ of space qualifies as the spatial analogue of the passage of time for it is a property of space that shows sufficient similarity to temporal passage. The similarity is particularly evident when we acknowledge that:

- The expansion of space is on-going (compare — time advances on and on);
- The expansion of space occurs throughout the universe (compare — time advances everywhere); and
- The metrical distance of the spatial extension since the beginning of the universe (due to the expansion) provides a quantitative counterpart to the (cosmic) time interval from the beginning of the universe [Riggs, 1984].

This answer of what constitutes the spatial analogue does not seem to have been previously offered in the literature about time.

Moreover, taking the expansion of space as the spatial analogue of the passage of time is justified irrespective of whether temporal passage is a fundamental aspect of reality or not! How can this be the case? The expansion is an empirically verified phenomenon which, of course, means that it does not depend on whether the Block View or the Dynamic View is essentially correct. The expansion of space, as measured by wavelength redshift (for example), occurs concomitant with the continual, ‘experienced’ (phenomenological) passage of time [Muller & Maguire, 2016: 2]. This phenomenological passage may be related to successive, quantitative time intervals measured by a suitable clock (as it is time intervals that are measurable and not temporal passage itself). The expansion of space will thereby hold as the spatial analogue of the passage of time regardless of whether one accepts the Block View or the Dynamic View but the formal interpretation of the spatial analogue will differ in these two views. The interpretation depends on each view’s theoretical premises. We will deal with the interpretations below.

Consider first the issue of possible locutions about the movement of space. A thorough search of English language dictionaries, thesauruses, phrase books, and even internet sites shows that there are no common locutions such as ‘the march of space’, ‘the passing of space’, ‘the flow of space’, ‘space rushes by’, or ‘space flies’, as Dainton indicated. Now that the spatial analogue of temporal passage has been identified, we should ask why there are no *common* sayings about ‘moving space’. Given the revelations of relativistic cosmology, we

may state a very straight-forward explanation for the absence of such locutions in everyday language. We do not have these (and other) ‘figures of speech’ about space, not because there is no spatial analogue of the passage of time, but because the relevant phenomenon (i.e. the expansion of space) is totally imperceptible in daily life [Smeenk, 2013a: 614]. Without this perception, the thought would *never occur to anyone* to create phrases about ‘moving space’!

It is the case that the Block View fits snugly with the spacetime interpretation of relativity theory [Pooley, 2014: 517], i.e. as a four-dimensional continuum in which all events exist (tenselessly) rather like an extended landscape [Greene, 2004: 138-139]. The historically assumed absence of any spatial counterpart to the passage of time has never been a concern for advocates of the Block View. Since temporal passage is not an objective feature of the universe to them, no spatial analogue was expected. The increase of the universe’s spatial volume would be interpreted in the Block View as successive global spacetime ‘slices’ of the universe having a bigger spatial (i.e. three-dimensional) cross-section at later values of cosmic time. Yet, existing as we do within the Block, we have a perspective of time that gives rise to a (subjective) awareness of passage for which the expansion of space provides a corresponding ‘progression’. Since the passage of time is only realised at a phenomenological level in the Block View, the existence of a spatial analogue does not bring with it any ontological implications.

The interpretation in the Dynamic View will differ ontologically (since future events and entities do not exist in this view). The expansion of the spatial volume of the universe would be interpreted as occurring, i.e. *coming into being*, with the (assumed objective) passage of time. Therefore, the existence of the spatial analogue sits very well with the Dynamic View for then space has a real and corresponding dynamic nature which parallels temporal passage. The historically assumed absence of any spatial counterpart to the passage of time would have been put down, by advocates of the Dynamic View, to just being one of the differences between space and time.

Relativistic cosmology has been looked to, for some decades, in the expectation that it might assist in resolving portions of the long-running debate between the Block and Dynamic Views. The definition of cosmic time in relativistic cosmology brought the hope that it might perform the role of a universal time, which would provide a framework to physically base temporal becoming. Unfortunately for advocates of the Dynamic View, it has been shown that cosmic time is not able to perform this role [Dieks, 2006: 168]. The objectivity of the passage of time still remains un-established [cf. Peterson & Silberstein 2010].

Well then, can the spatial analogue of the passage of time assist the Dynamic View? It has been previously claimed that the fortunes of the concept of the passage (or flow) of time would be boosted *if* it could be shown that there is an objective spatial analogue [Schlesinger, 1983: 117]. Since the expansion of space is an objective phenomenon, this might be put forward as supporting the reality of temporal passage. There appears to be at least one major difficulty with this proposal. In the Dynamic View, time necessarily ‘flows’ in some sense [Taylor, 1992: 80; Craig, 2000: 249; Fiocco, 2007: 15] and its spatial analogue would likewise be expected to be necessary in the same sense. However, the expansion of space is a contingent phenomenon, e.g. the universe could have been static as has been indicated by some relativistic universe models. Consequently, although the expansion of space does provide the spatial analogue of the passage of time, relying on the analogue as part of an argument in favour of the reality of temporal passage is not likely to succeed. It would be more reasonable to infer that the spatial analogue does *not* offer insight into the viability of a dynamic ontology of time.

Conclusions

The cosmological expansion of space is the spatial analogue of the passage of time. This analogue holds regardless of whether one accepts the Block View or the Dynamic View of time. There are no common locutions about the movement of space similar to those for time as cosmological expansion is completely unnoticeable at the scale of human life. The spatial analogue does not assist in deciding between these two competing realist views of time.



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